The need to uplift quality control and quality assurance for specialized concrete crack repair in the South African construction industry

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Abstract. Concrete patch repair is becoming an ~~very~~ important facet of the civil construction industry when considering the ~~very~~ large quantity of exposed concrete surfaces requiring maintenance and rehabilitation during its design life cycle. Patch repairs are more often than not done with a specialized polymer-modified mortar which requires adequate quality control and quality assurance during application and curing to ensure long-term success. Unfortunately, there have been many patch repair projects where there has been poor performance of the patch repairs resulting in ~~. D~~debonding, cracking and discolouration~~. are evidence of such poor performance.~~ In this paper, poor or inadequate quality control during the patch repair process is investigated as one of the possible reasons for ~~this~~ poor performance and premature failure . It is postulated that because of the lack of adequate knowledge and understanding of the repair material and the repair process by the various stakeholders (applicator, supplier, consultant and client), deficiencies in the quality control and quality assurance before, during and after the repair project often exists. In many patch repair projects, the responsibility for the successful completion of the patch repair work and the assessment of long term performance of patch repairs is not fully embraced by all of the parties involved.

This postulation has led to the research, by using questionnaires designed specifically for the four different stakeholder categories of the concrete repair industry. The results indicate that there is very little discussion amongst the stakeholders regarding quality control and acceptance criteria when performing concrete patch repairs, neither for the identification of patch repair failure directly after the completion of the patch repair, nor for long term performance of the patch repairs.

Introduction

~~Currently, in~~ In South Africa, there are currently no standards, guidelines or recommendations for condition surveys, repairs and maintenance of concrete patch repairs unlike our European counterparts that have EN 1504 available to them [1,2]. At this point in time in South Africa, it is often the responsibility of the engineer on site to sign off on every step of the repair process, thereby relieving the other role players from any accountability regarding performance and quality. It is impossible for the engineer alone to be sufficiently experienced and trained on every single step involved in the patch repair process. This fact leads to deficiencies in quality control of all the processes involved in polymer-modified concrete patch repairs. It, in turn, gives rise to poor

reliability in the design of the repair system, the choice in materials, the actual repair and the maintenance of the repairs. If a single step in the repair process is carelessly performed it will lead to poor serviceability of the structure [3,4]. Ramakumar states that: “reliability considerations can be beneficial in almost all stages of engineering endeavours”[5]. With this being said, it is important to ensure that all the stages of the repair process are considered, as set out in EN 1504 in an attempt to ensure reliability. O’Çonnor states that human operations, particularly repetitive, boring and unpleasant tasks, are frequent sources of variability [6]. This variability in the repair work definitely also affects the quality of the patch repair. In view of the fact that the engineer is not on site every day during ~~of~~ the duration of the project, it gives rise to the possibility of inadequate workmanship and workers not following proper procedures which will lead to the patch repair failing, and costly repairs [3].

Research methodology

This research project made use of four different questionnaires, each one designed specifically for a different stakeholder within the concrete repair industry. The four different stakeholders are clients, consultants, applicators and suppliers of the repair materials.

~~It must be mentioned at this point that~~ ~~a~~All four questionnaires were~~as~~ designed under the supervision of STATCON, a statistical consulting agency~~department~~ within the University of Johannesburg. STATCON specializes in the design of questionnaires and the statistical analysis of data. The rationale behind this was to have professionals lead in the design of the four different questionnaires to ensure that the wording of the questions, as well as the possible answers that were provided to the respondents do not lead the respondent in any way. This would theoretically ensure that unbiased answers are received from the respondents.

Although much more information was gathered from these questionnaires than what is presented in this paper, the goal of the section of the four questionnaires presented in this paper was to gather more information regarding the quality control of polymer-modified concrete patch repairs. This goal was achieved by asking the following six questions:

QUESTION 1: Do you spend time with the prospective client to discuss when a concrete crack repair is acceptable and when it has failed?

QUESTION 2: How often is the concrete crack repair integrity checked? Once every……

QUESTION 3: In your personal opinion, when has a concrete crack repair failed?

QUESTION 4: Are these criteria documented in the contract?

QUESTION 5: Do you revisit concrete crack repairs that are completed to determine if they are still effective?

QUESTION 6: What type of system does your company have in place whereby the concrete crack repairs are monitored for effectiveness?

Results and Analysis of Results

Table 1 indicates the response rate to the questionnaire for each of the four different sectors. Clients had a very low response rate, but the other three sectors had acceptable response rates. As mentioned above, the questionnaires were set up in such a way that they do not lead individuals in

any way, however, it must be noted that the researchers were still dependent on the honesty of the individuals answering the questionnaires, which is a disadvantage when using questionnaires in gathering information.

Table 1: The response rates to the questionnaires of the four different sectors in concrete patch repair.

	Consultants	Contractors	Clients	Suppliers of repair materials
Contacted	102	119	130	152
Replied	37	30	16	34
Response rate (%)	36	25	12	22

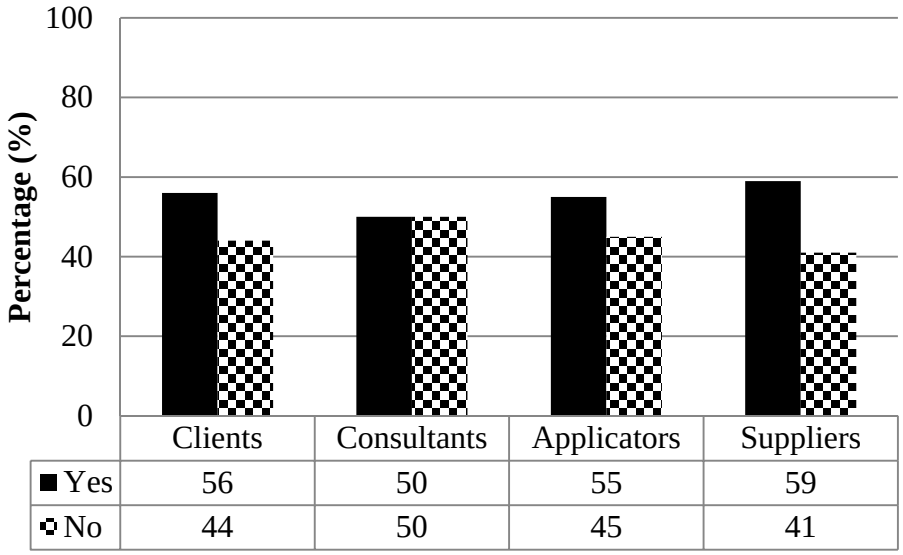
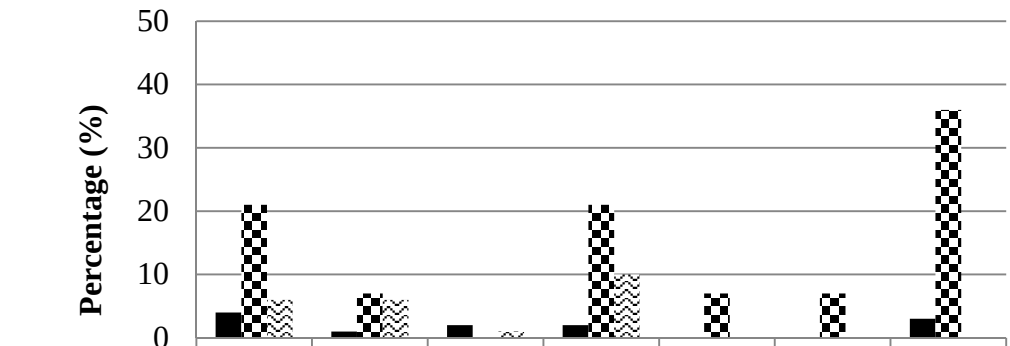


Figure 1: Time spend with prospective clients discussing the criteria for patch repair failure (Question 1)

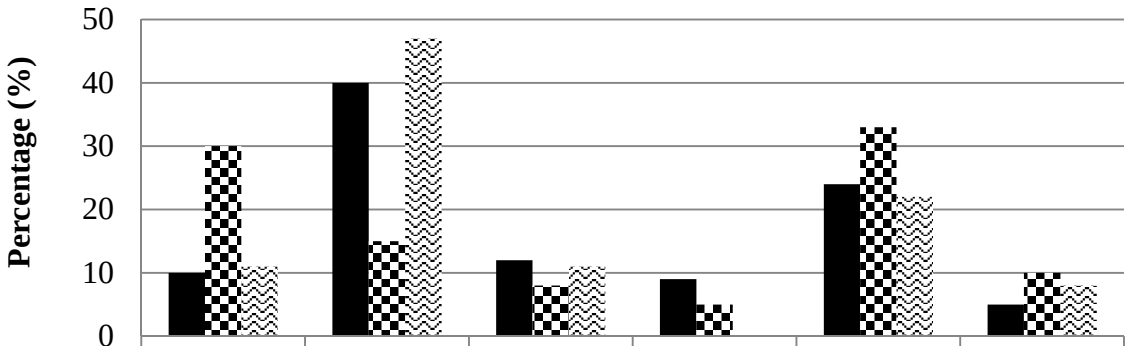
As can be seen from Figure 1, more than 50%~~halve~~ of the consultant respondents do not discuss acceptance criteria with prospective clients. This ~~figure~~percentage only slightly increases for applicators and suppliers. This lack of discussing the acceptance criteria for acceptable performance of the polymer-modified concrete patch repairs beforehand can most definitely lead to deficiencies in quality control and quality assurance. This in turn may lead to patch repairs not fulfilling the expectations of the client.



	1 - 4 weeks	5 - 12 weeks	3 - 6 months	7 - 12 months	13 - 18 months	19 - 24 months	> 24 months
Clients	4	1	2	2	0	0	3
Consultants	21	7	0	21	7	7	36
Suppliers	6	6	1	10			

Figure 2: How often is the concrete crack repair integrity checked? (Question 2)

Figure 2 indicates that most clients and suppliers do not check the integrity of the polymer-modified concrete patch repair materials. This value increases to 21% for the consultant respondents, which is still a very low percentage~~figure~~. There is no data for periods greater than 12 months for suppliers seeing that the questionnaire requested data for ~~asked~~ the suppliers for only ~~up to~~ 12 months, and not beyond this time period. This unacceptable low percentage for checking the integrity of the patch repairs most definitely will lead to poor knowledge regarding the long term performance of the polymer-modified patch repairs.

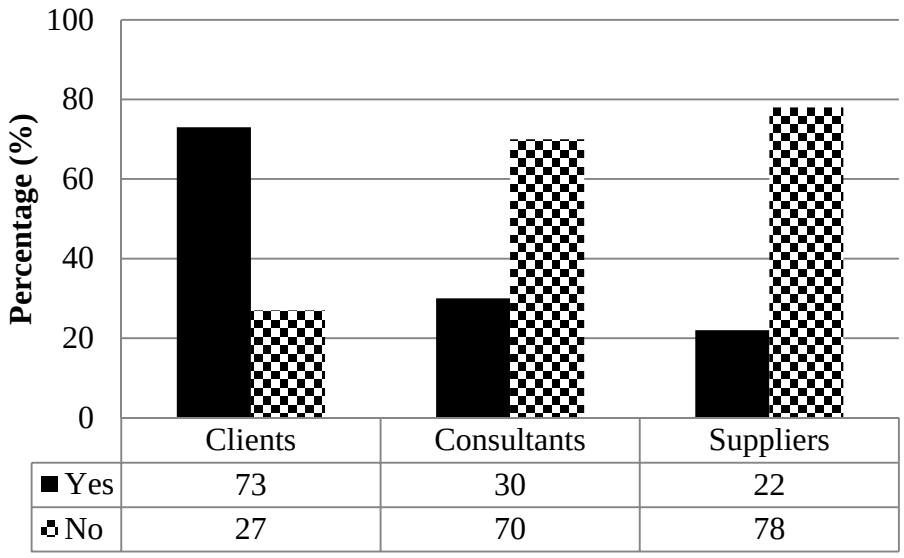


	Crack <1mm	Crack 1-6mm	Crack > 6mm	Discoloration	Delamination	Other
Consultants	10	40	12	9	24	5
Applicators	30	15	8	5	33	10
Suppliers	11	47	11	0	22	8

Figure 3: When has a crack repair failed? (Question 3)

Figure 3 indicates that there is no consensus on when a patch repair has failed. Very few consultants and suppliers acknowledged that patch repairs has failed when a crack less than 1mm has developed. This value~~figure~~ triples for applicators whilst t~~. T~~he vast majority of stakeholders stated that a crack had to be greater than 1mm to be considered a failure. Interestingly, no supplier respondent thinks that discoloration can be seen as a failure. Combining~~e~~ the results of Figure 3 with the poor discussion surrounding when a patch repair has failed as per Figure 1, and the ~~merry~~

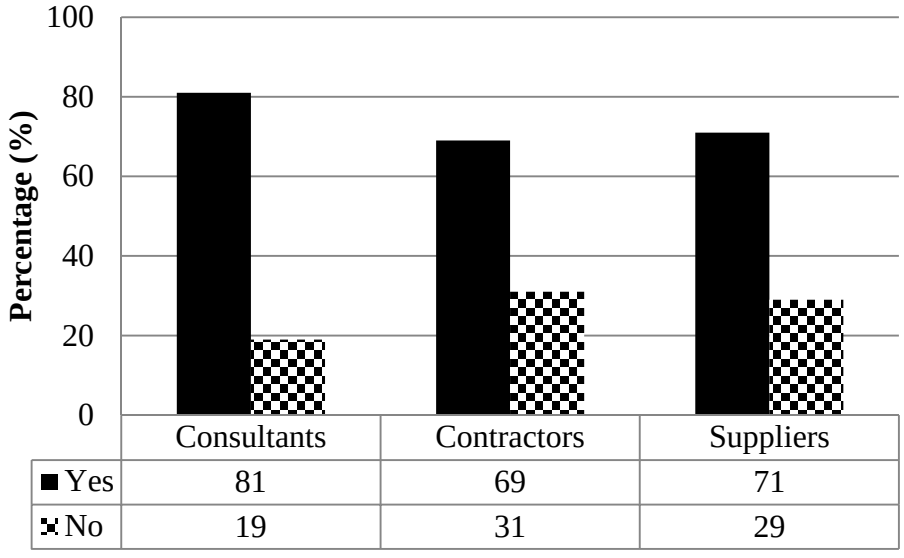
medley of different times that integrity of patch repairs are checked, it most definitely will lead to poor long term performance, as well as the possibility of expensive further remedial work and even litigation.



	Clients	Consultants	Suppliers
Yes	73	30	22
No	27	70	78

Figure 4: Is the criteria of failure taken up in the contract documentation? (Question 4)

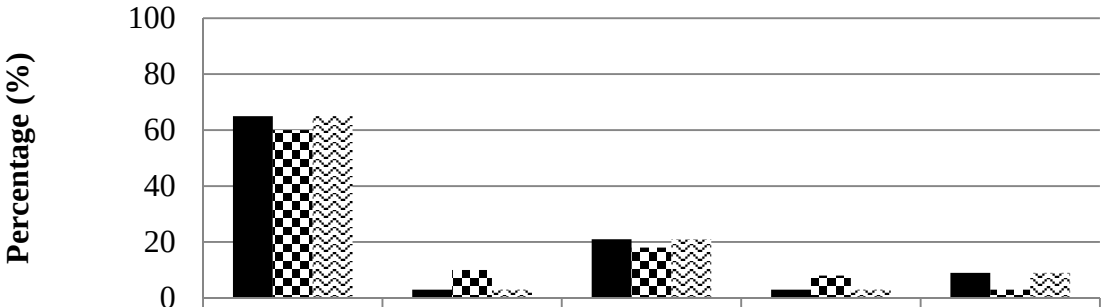
An unacceptably low percentage of consultants and suppliers have indicated that the failure criteria of the patch repairs are incorporated into the contract documentation, as can be seen from Figure 4. This could lead to poor identification of patch repair failure, which in turn will influence the long term performance.



	Consultants	Contractors	Suppliers
Yes	81	69	71
No	19	31	29

Figure 5: Revisit concrete patch repairs for effectiveness (Question 5)

Figure 5 indicates that many consultants, contractors and suppliers do revisit concrete patch repairs for effectiveness. The method of assessing effectiveness would play an important role in establishing the effectiveness of concrete patch repairs.



	Visual	Sounding test	Non-destructive testing	Destructive testing	Other
Client	65	3	21	3	9
Consultanrs	60	10	18	8	3
Applicators	65	3	21	3	9

Figure 6: Type of test used for assessing patch repair effectiveness (Question 6)

Figure 6 indicates that the vast majority of clients, consultants and applicators use visual assessment of the patch repairs as a test to determine if the patch repair is still effective. This is most definitely not enough. Some non-destructive tests will need to be carried out to be able to access the effectiveness of the concrete patch repairs. Using only visual methods will lead to poor and incomplete information regarding debonding, crack patterns and crack depths.

Conclusions

The results indicate that there is very little discussion amongst the stakeholders regarding quality control and acceptance criteria when performing concrete patch repairs, neither for the identification of patch repair failure directly after the completion of the patch repair, nor for long term performance of the patch repairs. No adequate system exists or is utilized by any of the stakeholders for ongoing evaluation of repair system performance. Thus it is concluded that quality control and quality assurance in concrete patch repair projects are revisited and improved as a matter of urgency to ensure sustainable and effective patch repair procedures.

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